Fil : 3037.VSD   EL978317630US

D cket N . AUS920030740US1
Langdale t al.
System and Meth d f r JIT M m ry F tprint Impr v ment for Embedded Java Devices

1 / 10
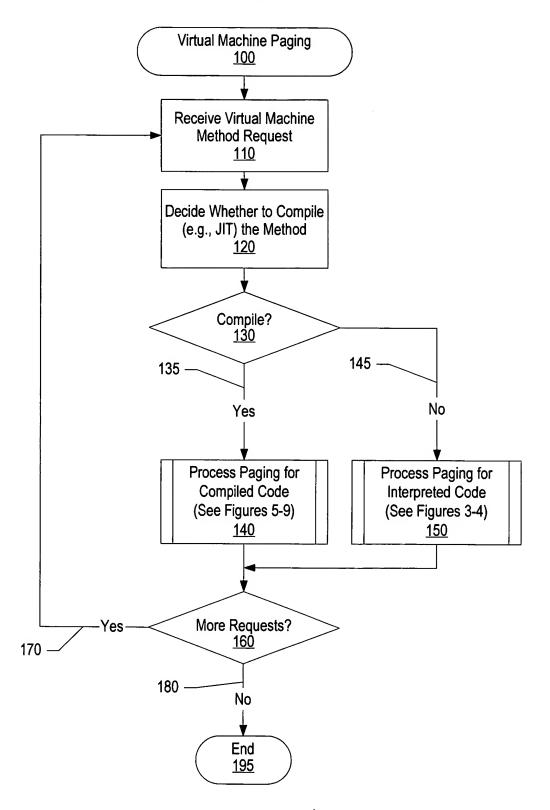

Figure 1

File: 3037.VSD

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System and Method f r JIT M mory F   tprint Impr v m nt f r Embedd d Java D vic s

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Memory Map
200

Kernel
202
Filename of Program
204
Environment
206
Arguments
208
Data Binding Info.
210
Stack
212
⋮
Memory Mapped
JIT Pages
230
⋮
Memory Mapped
JXE File
250
⋮

Special JIT Filesystem
(JITFSD)
220

JIT Cache
225

Real Filesystem
235

JXE File
240

Program
Library
260

Java Virtual
Machine
(JVM)
280

BSS 272
Data 274
Text 276

270

Java Heap
292
BSS 294
Data 296
Text 298

290

⋮

Figure 2

Fil : 3037.VSD

D ck t N . <u>AUS920030740US1</u>
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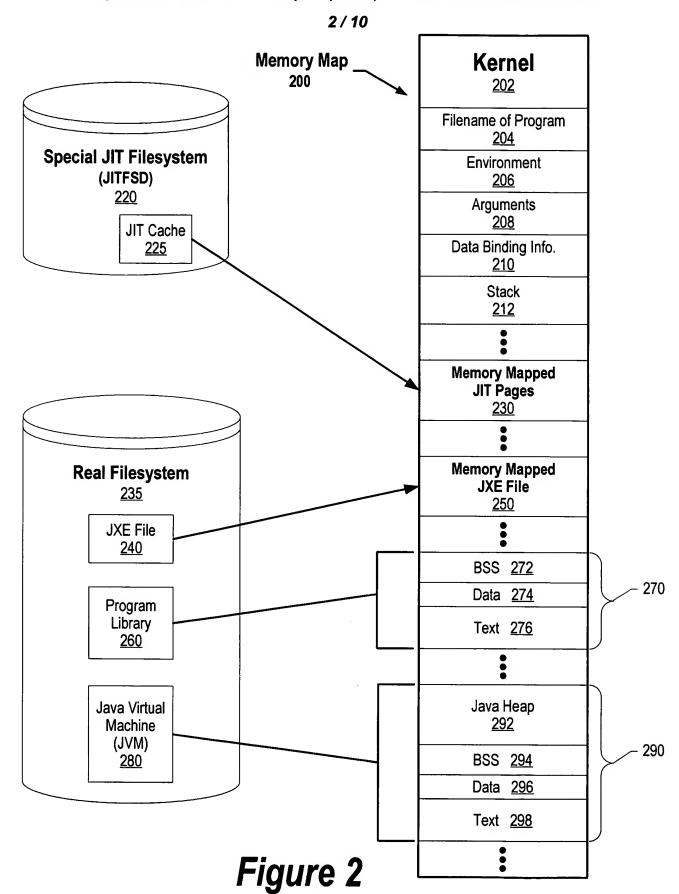
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Memory Needed

- O/S Selects and Discards Previously Loaded Pages.

- Allows System Paging to be Applied to Java Bytecodes

<u>370</u>

Memory Map
Map Entire R/O (Code) Section of File to Memory Using R/O Mapping
<u>330</u>

(3)

(1)

Read-Only Section (e.g., bytecodes)
<u>310</u>

Read-Write Section (e.g., variables)
<u>320</u>

Executable Image (e.g., JXE file)
<u>300</u>

—mmap—

—Read Pages (as needed)—

Device Memory (RAM)

(See Figure 2 for Memory Map Details)
<u>350</u>

(2)

Page Reads

- Startup, e.g., call of main(), or Call of Any Unloaded Code Causes Page Fault

- O/S Page Fault Handler Reads in Needed Page Due to Memory Mapping
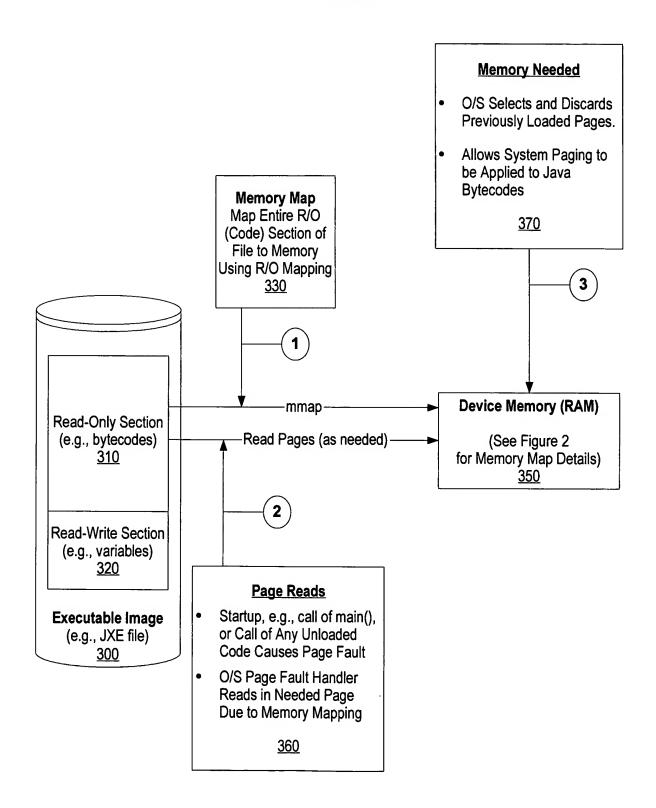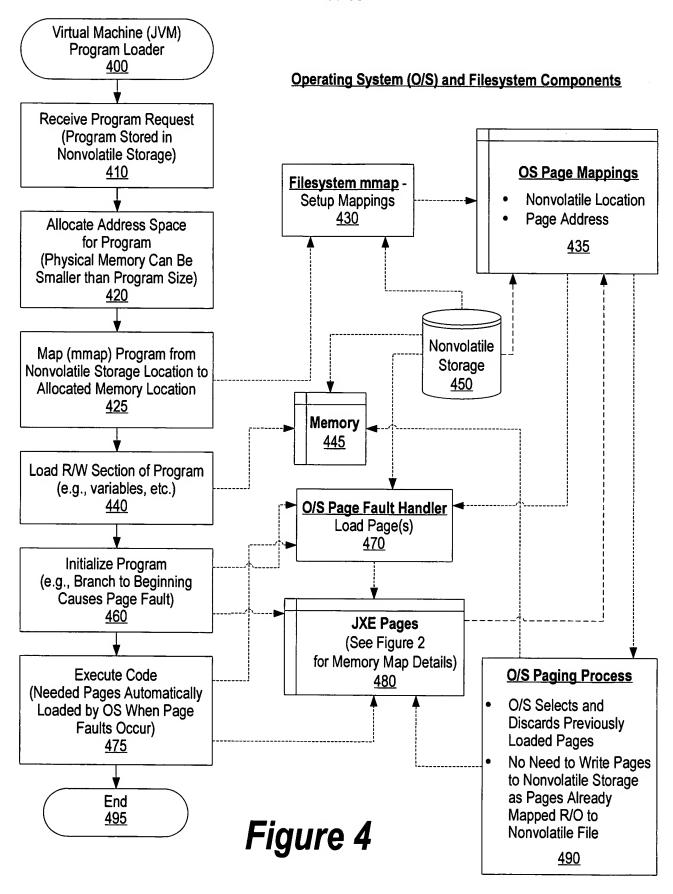
<u>360</u>

Figure 3

File: 3037.VSD

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Virtual Machine (JVM)
Program Loader
400

Receive Program Request
(Program Stored in
Nonvolatile Storage)
410

Allocate Address Space
for Program
(Physical Memory Can Be
Smaller than Program Size)
420

Map (mmap) Program from
Nonvolatile Storage Location to
Allocated Memory Location
425

Load R/W Section of Program
(e.g., variables, etc.)
440

Initialize Program
(e.g., Branch to Beginning
Causes Page Fault)
460

Execute Code
(Needed Pages Automatically
Loaded by OS When Page
Faults Occur)
475

End
495

Operating System (O/S) and Filesystem Components

Filesystem mmap -
Setup Mappings
430

OS Page Mappings
• Nonvolatile Location
• Page Address

435

Nonvolatile
Storage
450

Memory
445

O/S Page Fault Handler
Load Page(s)
470

JXE Pages
(See Figure 2
for Memory Map Details)
480

O/S Paging Process
• O/S Selects and
  Discards Previously
  Loaded Pages
• No Need to Write Pages
  to Nonvolatile Storage
  as Pages Already
  Mapped R/O to
  Nonvolatile File

490

Figure 4

File: 3037.VSD

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Initialize JVM
500

Initialize Virtual Machine
(e.g., JVM)
510

Filesystem
(JITFSD)
540

Execute Programs Using Virtual Machine
520

JIT Compiler
(See Figure 6)
530

-----mmap-----

-----Mapping Data-----

Re-JIT

Exception Handler
• Retrieves Code Based
Upon Faulting Page
Address After Page
Discarded by O/S
570

JITed Code
(Discardable
by O/S)
550

Mapping of
Files & Pages
560

End
595

Figure 5

Fil : 3037.VSD
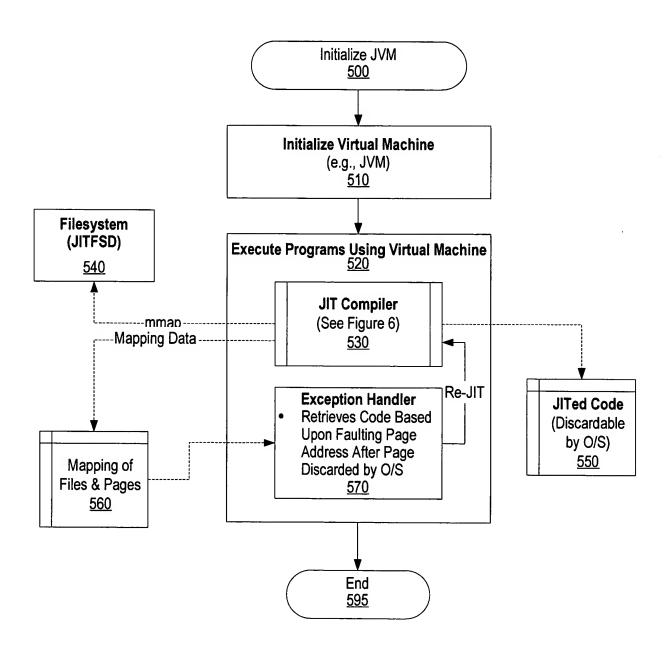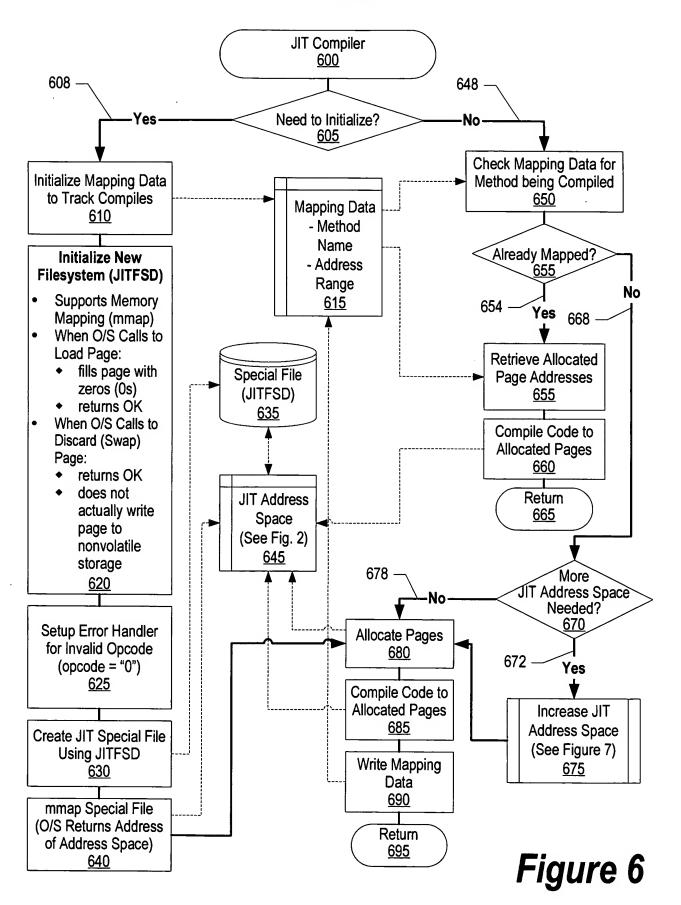
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System and M th d f r JIT Mem ry F tprint Impr vem nt f r Emb dd d Java D vic s

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Figure 6

File: 3037.VSD

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System and Meth d for JIT M m ry F tprint Impr vement for Emb dd d Java D vic s

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Increase JIT Address Space
700

JVM Usage
Statistics
720

Retrieve Usage Statistics
for Compiled (JITed) Code
710

Seldom
Used JITed Method(s)?
725

758

No

728

Yes

Mapping Data
- Method
Name
- Address
Range
740

Reclaim Address Space by Removing Entry
for Each Identified Seldom Used Method
730

790

Enough
Space Reclaimed?
750

752

Yes

No

Special File
(JITFSD)
765

Create Another JIT Special
File Using JITFSD
760

New JIT
Address
Space
775

mmap Special File
(O/S Returns Address of
Another Address Space)
770

Initialize Mapping Data to
Track Compiles into Newly
Created Address Space
780

Map for New
Address
Space
785

Return
795

Figure 7

Fil : 3037.VSD

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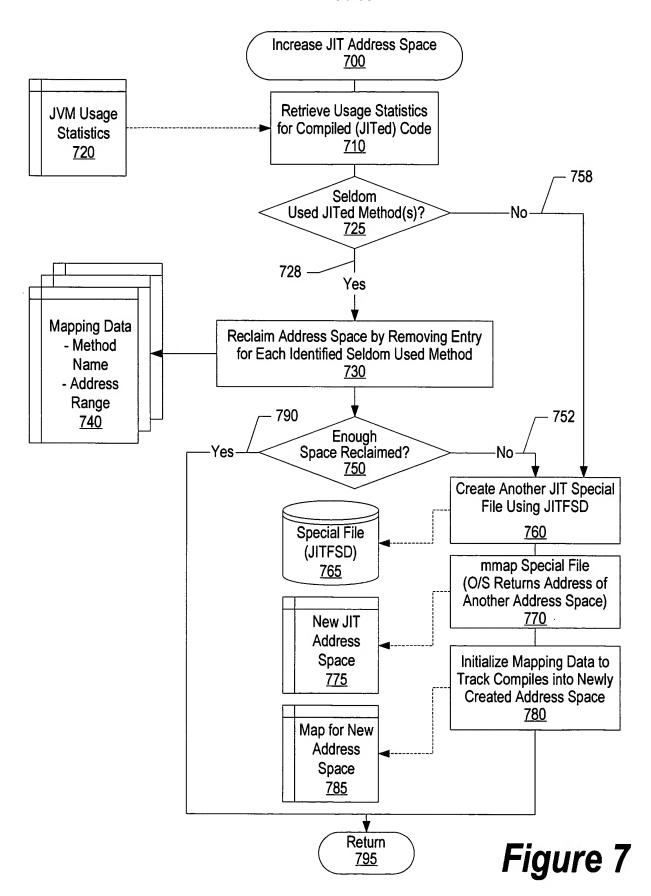System and M th d f r JIT Mem ry F tprint Impr vement for Embedd d Java D vic s

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OS Memory Manager
(Memory Reclamation)
800

Filesystem (JITFSD)
840

Identify JIT Heap Page(s)
to Discard (Reclaim)
810

Receive Notification
• Do Nothing with
  Page(s)
• Do Not Swap to
  Disk, etc.
850

Instruct Filesystem to Write
Pages to Disk
830

JIT
Address Space
820

Return "OK" Reply
(i.e., "Successful"
Return Code)
860

Receive Return Code
880

End
870

Discard JIT Heap Page(s)
890

End
(Memory Reclamation)
895

Figure 8

```
                        OS Memory Manager
                        (Page Fault Handler)          Filesystem (JITFSD)
                               900                            920

   JVM                   Detect Page Fault            Receive Read Request
 Application            (Code Branch to                       925
    910        ─ ─ ─ ▶   Non-Loaded Page)
                               905

                        Call Filesystem to            Fill Page(s) Requested
 Error Handler              Handle                    to Load with Zeros (0s)
(Invalid Opcode "0")      Page Fault                          930
       960                    915

 Receive Error and      Receive "OK"                 Return "OK" Reply
 Page Address           Reply from                    (i.e., "Successful"
      965               Filesystem                    Return Code)
                            940                             935

 Lookup Method Name
 in Mapping Table       Restart Instruction                 End
      970               that Caused Page                    938
                        Fault
                            945
         ─988
 Fault at               Receive Error:
Beginning of Method? ─No Invalid Opcode
      975                   950
                   978
     Yes        986─
                    Yes─▶Call Registered
 Re-JIT Code? ─────      Error Handler
      980                    955
            ─982
      No                    End
                            958
 Run Java Bytecode,    Re-JIT Code
 Remove Mapping Data   (See Figure 6)
      985                   990

                        Restart Instruction
      End               that Caused
      998               Page Fault
                            995
```
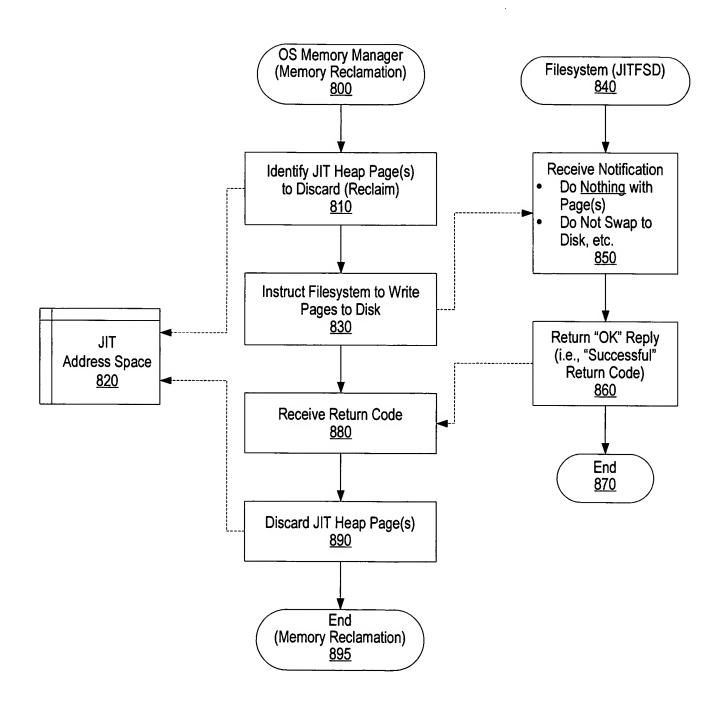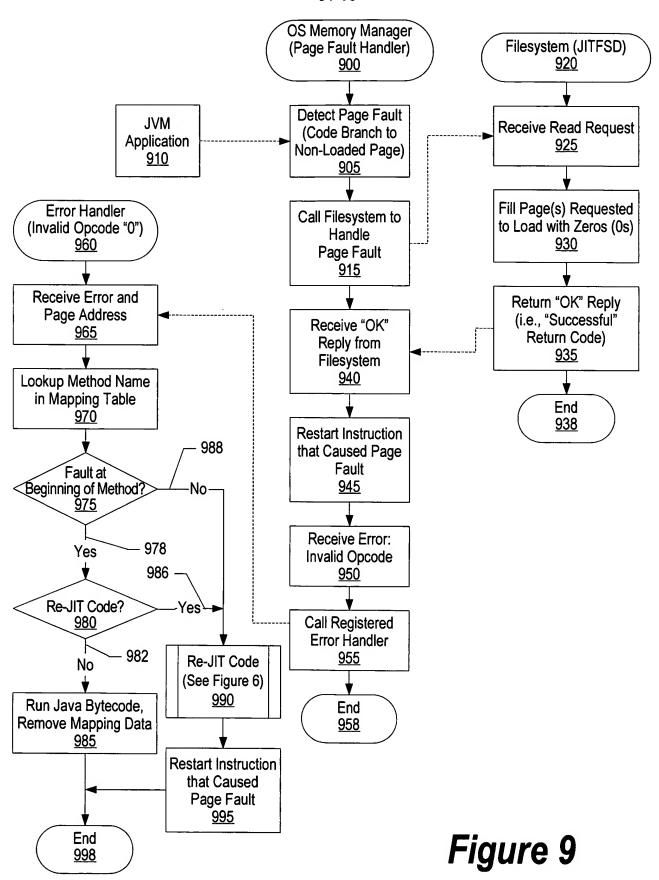
Figure 9

File: 3037.VSD

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System and Meth d f r JIT Mem ry F tprint Impr v ment for Embedd d Java Devic s

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1022

JTAG/I2C Busses

Processor(s)
1000

1001

1002

Host Bus

Level Two Cache
1004

JTAG/I2C Busses

Main Memory
1008

Host-to-PCI
Bridge 1006

JTAG/I2C Busses

JTAG/I2C Busses

101 0

PCI Bus

Service Processor
Interface & ISA Access
Passthru
1012

LAN Card
1030

101 4

PCI Bus

Service
Processor
1016

Flash
Memory
1018

PCI-to-ISA
Bridge

1035

1055

USB 1045

1090

ring

Modem 1075

NVRAM
1020

1064

Serial

Parallel 1062

ISA Bus

1040

Mouse

Keyboard

1070

1068

Figure 10